INSTRUMENTS

THE MAGAZINE OF MEASUREMENT and CONTROL

VOLUME 10

NOVEMBER

1937

NUMBER 11

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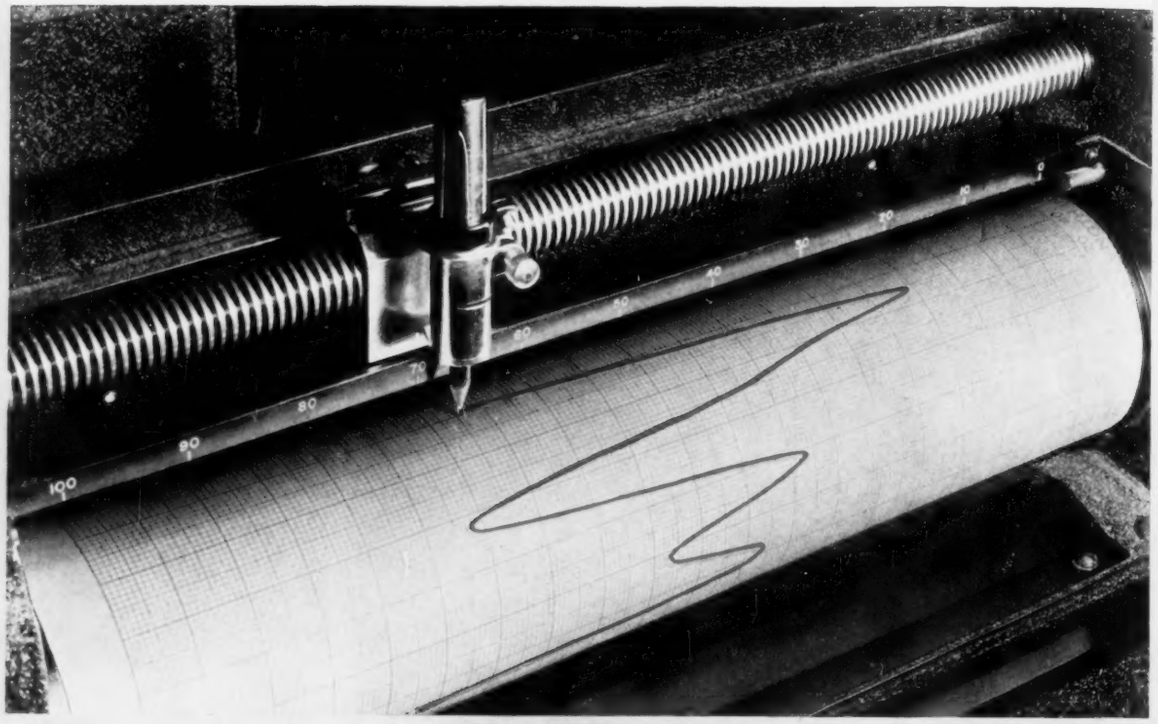

MAUVE, orchid, vermilion, the infinite varieties of gray and white—all these yield their secrets to a measuring instrument invented by Prof. A. C. Hardy of M.I.T. and developed for commercial application by General Electric measurement engineers. Manufacturers of colored inks, of paper, of paints, and of textiles can trust the colors if the color values are checked by the recording photoelectric spectrophotometer—the instrument that analyzes color and writes an exact color *analysis*.

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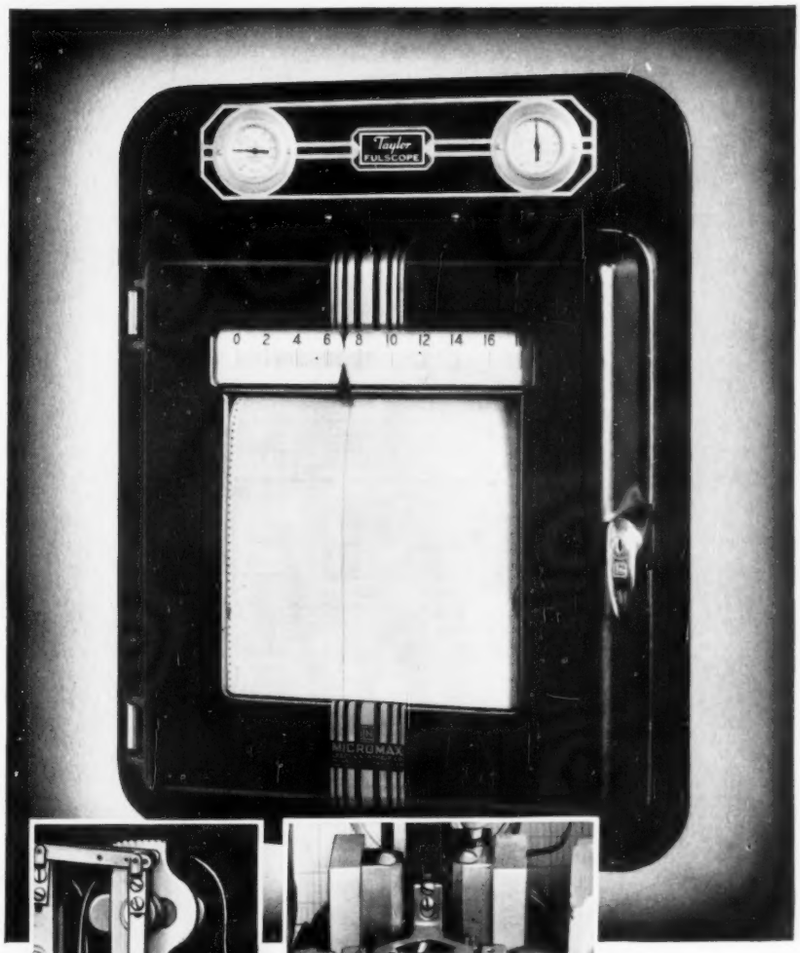

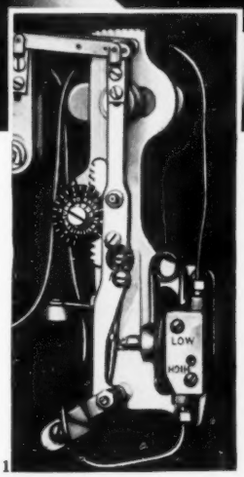

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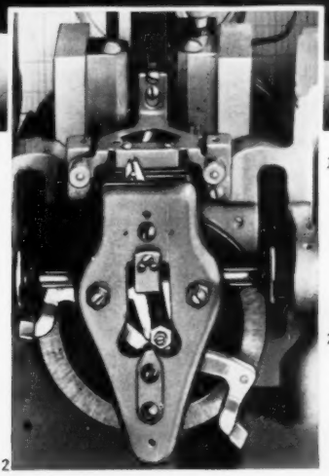

2

1 The Taylor Fulscope Controller contributes its Universal Sensitivity Adjuster to the new Taylor Fulscope Micromax Controller.

2 The simple, sturdy Micromax galvanometer unit is standard in the new Taylor Fulscope Micromax, the air operated potentiometer controller.

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INSTRUMENTS The Magazine of MEASUREMENT and CONTROL

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INSTRUMENTS The Magazine of MEASUREMENT and CONTROL

M. F. BEHAR
EDITOR

IN THIS ISSUE

"When are you going to give us a Special Issue on Industrial Optical Instruments?" we've been asked for many months. Well, this is *almost* it: (1) Resch discloses some little-known metallographic possibilities of the comparison microscope, of interest to readers who aren't yet in position to acquire a complete metallographic equipment. (2) Logan announces a short-cut method for computing spacer-ring length. (3) Hill's ingenious dark-room timer is not strictly optical but will interest many readers in optical and other fields. (4) Professor Williams starts discussing modern scratch-hardness methods by describing one that involves the use of a microscope. . . . Messrs. HWG, BMcA, RSB and other recent suggestion-givers please note that there's not one electrical circuit diagram in these four articles or in the other editorial contents of this issue! (Aside to others: you'll get *your* wish soon!)

A new department starts in this issue (page 292).

THE FRONT COVER

shows the air-conditioning instrumentation in the beautiful new Federal Reserve Board Building, Washington. A handsome bouquet from *Instruments* to Harry Alexander, Inc., the contractor; to Moody & Hutchinson, the engineers; and to the Bristol Co., instrument-makers, who give us the following details:

(Left) Three electric flow telemetering systems, each consisting of an indicator-integrator and of a separate recorder, their primary elements and transmitters being installed on condenser and chilled-water lines.

Ten Bristol "Wide Strip" resistance-thermometer recorders, recording not only several dozen air and water temperatures in the system and in the building, but also outside dry-bulb and outside wet-bulb temperatures, in sun as well as in shade.

(Extreme right) One Bristol edgewise-form indicating resistance thermometer; below it 72 key switches enabling observer to "take" temperatures through the entire building and throughout the ventilating and conditioning system.

ANTI-PROGRESS??

IN our September editorial we came out strongly against governmental restriction of labor-saving inventions. We remarked that technological progress has both friends and enemies in Administration circles. We praised F. Stirling Wilson of the Bureau of Foreign and Commerce; and—by implication—attacked the President's National Resources Committee for its "Social Implications of New Inventions."

In fairness, we print here *adequate* extracts from an address by Professor Charles E. Merriam, member of the Committee (not to be confused with Dr. John C. Merriam, its Chairman) before the American Institute in New York on October 19:

Among these findings of the committee are . . . (2) The "immigration of iron men" will continue to cause great elimination of occupations and industries, while at the same time it will create other occupations, services and industries. (3) To avoid occupational obsolescence and capital obsolescence in distressing degree, systematic attention by the Government and others must be given to adaptation and adjustment of inventions to economic and social life. . . . (7) There is usually opportunity to anticipate the impacts of inventions upon society, since they never come instantaneously without signals, but usually may be anticipated by a period of some thirty years. . . .

It is recommended that the whole problem of technological unemployment be carefully studied by a joint committee from the Departments of Labor, Commerce, Agriculture, the Bureau of Mines, the Interstate Commerce Commission, the Social Security Board, and the Works Progress Administration.

. . . These inventions open the door to incalculable wealth and opportunity and indefinitely higher levels of human happiness if we are able to utilize them in the fullest possible measure. This utilization will not come by chance, however, but requires the most earnest and comprehensive consideration by responsible groups of competent persons, both in and outside the government. . . .

. . . It has never occurred to us that the government should endeavor to monopolize or control indirectly all research and invention. On the contrary it has been thought that every effort should be made to encourage research and invention by every available agency, public, quasi-public or private, industrial, academic, institutional or otherwise, both in natural sciences and in social science; and that the government should use its friendly offices for the purpose of assisting them. . . .

Speaking for myself only, I should like to see further inquiry into the incidence of technological unemployment and how to make sure that the gains of civilization do not become the burdens of those upon whom the necessity of adaptation first falls. If a mechanical device reduces employment from 2,000 to 200, we must not place the load upon the shoulders of the 1,800 who are out of a job. Occupational obsolescence is a social risk, not merely individual bad luck. Something has already been done at this point but much more remains to be done. In an economy of abundance we must be on the lookout for new inventions which will satisfy new wants, develop new industries, new products, new services. . . .

The same civilization that produces mechanical inventions can surely with equal diligence and concentration produce social mechanisms adequate to the best social use of the new contrivance. . . .

The next phase of human history may witness the flaming out of fascist revolutions, the armed clash of economic nationalisms. . . . Or it may be characterized—and herein lies our hope—by the adroit avoidance through intelligence and courage of catastrophic collisions and perhaps débâcles . . .

Nevertheless we may repeat what we asserted in our September editorial:

It would cripple industry to have new methods and new devices passed upon by *any* dictatorial board in Washington. Even a board of geniuses would not have foreseen in 1912 the millions of new jobs created by the new industries in this quarter-century. And *who* is the super-genius capable of selecting the geniuses that will serve as Kommissars of Inventions?

Using a "FRAHM" Vibrating Reed Hand Tachometer

SIMPLY hold the Frahm Tachometer on some stationary part of a machine to measure r.p.m. of its rotating element . . . widely used on turbines and other totally enclosed machines.

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NEW INSTRUMENTS

In this department we strive to report each month ALL the new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions.

When writing to manufacturers directly, please mention this department as your source of information.

Or write to Information Section, Instruments Publishing Company.

Cold-cathode X-ray Diffraction Tube

An improved X-ray diffraction tube of the gas type is a modification of a design used for the past several years for metallurgical, mineralogical, crystallographic, and chemical analysis. Tube is self-rectifying and has a water-cooled cathode with provision for adjustable focus. New cathodes may be introduced without disassembling tube, by means of a tool which is provided. Targets are interchangeable, being fastened to a ground-in metal taper. Four optional targets are supplied as well as a generous supply of cathodes. Three windows of 0.0003" aluminum foil, all within $\frac{3}{4}$" of focal spot, allow an adequate number of X-ray beams of high intensity. Also supplied is a cast duraluminum bracket for mounting the tube, which is shipped assembled and tested. Makers can also furnish a vacuum system, suitable for the efficient operation of this tube and modifiable to suit user's laboratory equipment. —*Baird Associates, 20 Palmer St., Cambridge, Mass.*

Oven Control

Though developed for application to the ovens of domestic gas ranges, new "Visi-Therm" thermostat would seem to be suitable for some laboratory and small industrial gas-heated ovens by reason of its combining both control and indicating functions. No claims are made for extreme accuracy of temperature control. Design permits, however, faster pre-heating by reason of indicating pointer and ingenious arrangement of dual-purpose scale; and self-checking is made possible by alignment of indicating pointer and setting index.—*The Wilcolator Co., 17 Nevada St., Newark, N. J.*

Signal Generator

New Model PSG-15 has output calibrated in microvolts. This, together with power level meter, is said to give more measurements than any other signal generator now available. Sensitivity, gain-per-stage and selectivity are standardized by a self-contained vacuum tube voltmeter. Output ranges: R-f. $\frac{1}{2}$ microvolt to 100,000; a-f. 0 to 2.0 volts. Three

db ranges: —10 to +6; +6 to +22; +22 to +38. R-f ranges are calibrated directly 85 kc. to 28 Mc. Complete built-in power supply consists of transformer, rectifier and filter system. Case is 13" × 10" × 7".—*The Hickok Electrical Instrument Co., Cleveland, Ohio.*

Magnetic Gas Valves

New magnetic gas valves of silent solenoid design, Types V435 and V835, are offered in $\frac{3}{8}$", $\frac{1}{2}$" and $\frac{3}{4}$" sizes; are included in new "Gas Regulator Packages," known as Y77, Y78, Y79, designed for floor furnaces and circulating heaters. The Y77A consists of Type T45 snap action thermostat, V835 magnetic gas valve in smaller sizes, and an external transformer. The Y78 is made up of T801A Time-O-Stat with V835 gas valve and necessary fittings. Y79 is same as Y77 except that line-voltage type of magnetic gas valve is included in place of two-wire low-voltage type. New valves are furnished only in straight through pattern with screwed ends. Standard models are for 110 volts 50 and 60 cycles.—*Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.*

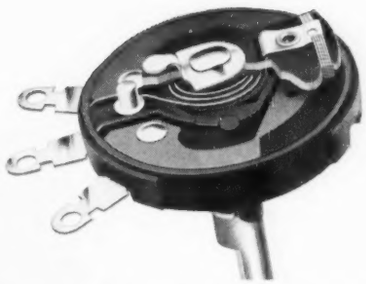
Control System

New Electr-o-Line system, electrical equivalent of Air-o-Line System (see *Instruments*, Sept. 1935, page 245), comprises following units: (1) A control

instrument designed to actuate (a) a proportioning resistor contact which assumes a definite position for each position of the control instrument pen or pointer, and (b) a reset contact which recognizes any departure from the control point and initiates necessary corrective action. (2) The Electr-o-Line Relay (illustrated) which links the control instrument to the motor mechanism. It is a sensitive electronic relay which responds to a slight change at the control instrument and energizes the motor mechanism through motorized mercury switches. (3) A reversible motor mechanism which operates the control valve. Normally, motor valve is in its half-way or average demand position when the control instrument is at the control point. However, if conditions require a different average valve position to keep the control point, this reset is produced automatically. Electr-o-Line Relay has following adjustments: (1) A throttling range adjustment varies the size of the valve step corresponding to a given movement of the instrument pen. (2) A rate of reset adjustment varies the rate at which the average valve position is changed in order to maintain the exact control setting. (3) A sensitivity adjustment determines the responsiveness of the relay to small changes at the control instrument. (This adjustment is distinctly different from the throttling range adjustment and is not to be confused with it.) A manual control switch permits operator to disconnect control instrument, and control manually without interrupting or upsetting the process. A switch indicator, visible through small hole in panel, shows whether valve motor is moving and in what direction. When adjusting sensitivity, operator can tell whether motor finds the balanced position immediately or hunts back and forth about this position.—*The Brown Instrument Co., 4482 Wayne Ave., Philadelphia, Pa.*

Volume Controls

New "Silent Spiral Connector" available on IRC Type C Volume Controls does away with sliding metal-to-metal contact and consequently with common source of noise: positive and continuous electrical connection is obtained between



center terminal and volume adjustment arm, instead of usual slide-and-friction contact.—*International Resistance Co., 401 N. Broad St., Philadelphia, Pa.*

Pressure Controls

Small-size ball-type additions to maker's line of reducing valves (*Instruments*, Nov. 1935, page 310) are announced in three forms: No. 400 spring form, No. 410 weight-and-lever form, and No. 420 liquid-column form, all available in sizes $\frac{3}{8}$" to $1\frac{1}{2}$" inclusive, and all suitable for steam, water, air, etc., for dead-end service. Tapered opening between ball and beveled seat, as well as unobstructed body passages, result in relatively large capacity with relatively low pressure drop. Worthy of special mention to *Instruments'* readers is maker's scientific basis of rating: on definite "percentages

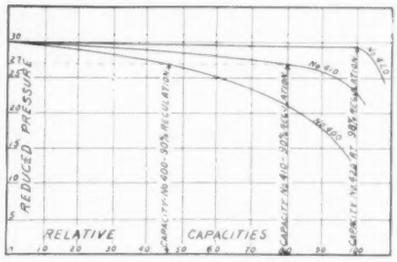


Fig. 1

of regulation" which means that limits of usable capacities are considered reached when reduced pressures fall to stated percentages of shut-off or dead-end pressures. Fig. 1 shows application of this basis to a 30-lb. pressure problem.

Another new pressure-control device announced at the same time is the "Excelator" which, installed near the outlet of a reducing valve as shown in Fig. 2, causes the pressure delivered by the valve

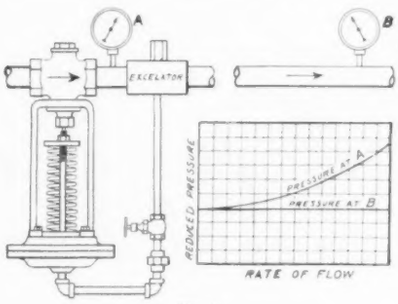


Fig. 2

(at *A*) to rise as the load (flow rate) increases, to compensate for pipe friction and thereby maintain desired pressure at remote point *B*. This device is available in sizes $\frac{3}{8}$" to $1\frac{1}{2}$" inclusive, for water, steam or air lines.—*Klipfel Mfg. Co., 2641-2659 W. Harrison St., Chicago, Ill.*

BAILEY METERS

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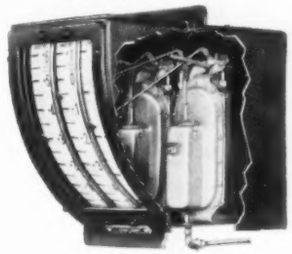
Boiler Meters Indicate, record and integrate Steam Flow from the boiler, record Air Flow supplied for combustion and record Flue Gas Temperature. The use of this meter reduces fuel cost, lessens maintenance and outage, lowers standby costs, and adds capacity.

Bailey Boiler Meter

Multi-Pointer Gages for indicating drafts, pressures, differentials are available with any number of pointers from one to twelve. They are actuated by sturdy yet sensitive diaphragm units.



Multi-Pointer Gage

Flow Meters. For indicating, recording and integrating the flow of steam, feed water, compressed air and other fluids.

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Control Systems. Make possible the everyday operation of equipment for steam generation and utilization at test efficiencies. They are applied to the control of combustion, feed water, superheat, desuperheat and other factors.

Complete Information on any of the above Bailey products will be gladly furnished upon request.

G-7

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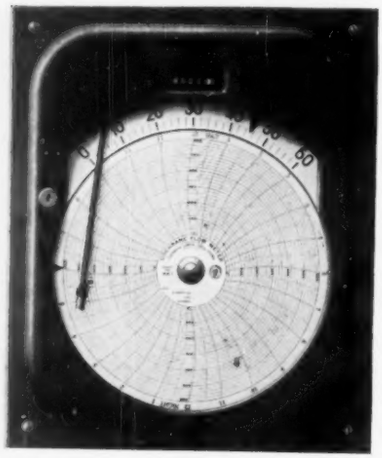

Cochrane Electric Flow Meters utilize the principle and have the sensitivity of the finest measuring instrument made—the chemist's balance. This exemplifies the galvanometer null principle upon which Cochrane Electric Flow Meters operate, universally recognized by scientists as the most accurate means of measuring a force or quantity.

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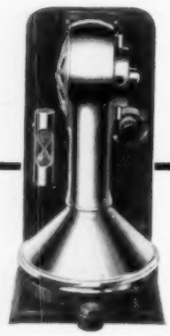

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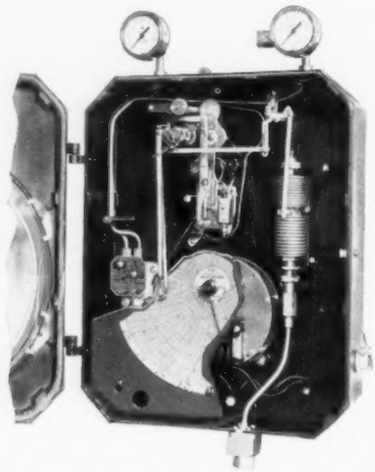
By reason of critical relationship between absolute pressure and physical properties of gases and vapors under low pressure, fluctuations in barometric pressure may lead to errors in measurement



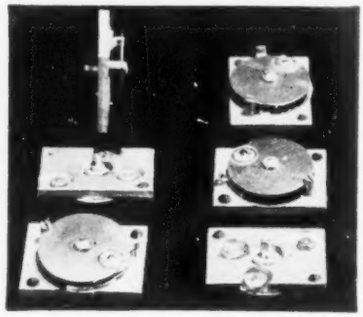
and serious variations in processing when "gage" and not absolute pressure is taken as basis. A new line of instruments for indicating, recording and controlling absolute pressure is announced to comply with advanced engineering practice. Absolute-pressure element consists of a flexible phosphor-bronze bellows to the inside of which the pressure medium under measurement is communicated. Connected with this assembly, and opposing its action, is a second identical metal bellows which has been evacuated and sealed, thus comprising an atmospheric-pressure compensator. New instruments are applicable to distillation units, evaporators, condensers, and in general, wherever the corresponding mercury type of gages can be used—with the exception, of course, of gases or vapors corrosive to the bronze bellows.—*Taylor Instrument Companies, 95 Ames St., Rochester, N. Y.*

Radio Set Tester

New "Model 1601" Triplett DeLuxe Set Tester (25,000 ohms per volt d. c.) has complete facilities for a-c. and d-c. voltage, direct current and resistance analyses, in addition to incorporating a condenser tester, free point tester and decibel meter. Instrument reads: d-c. volts, 10-50-250-500-1000-2000 at 25,000 ohms per volt; a-c. volts 10-50-250-500-1000-2000 at 1000 ohms per volt; 250 d-c. microamps; 1-10-50-250-500 D. C. milliamps; 1, 2 and 20 amps; 0-500 low ohms backup circuit; 0-20,000 and 0-200,000 ohms, 2 and 20 megohms; condenser capacity tester, 0.001 to 30 mfds.; electrolytic leakage test; decibel meter, down 10 and up 15; free point tester makes all series and parallel meter connections through five sockets with standard RMA markings. Set has front-illuminated indicating instrument with extra-large dial, and "shadowgraph meter" for line voltage control.—*The Triplett Electrical Instrument Co., Bluffton, Ohio.*

Crystal Oscillator Thermostats

Bimetallic thermostats and built-in heaters mounted in box containing oscillator crystal provide constant temperature and protect parts from atmospheric changes. Unit consists of a 1" diam. bimetallic thermostat with a mica-insulated heating element attached. Heating element operates either from a 6 or 12 volt battery and has a resistance of either



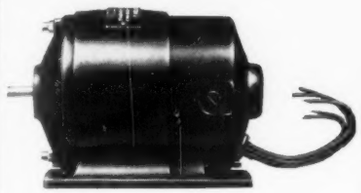
7½ or 30 ohms. Thermostat disk setting maintains temperature between 50 and 80° F., depending upon the application.—*Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.*

Solenoid Relay with Mercury Switch

An improved "Durakool" mercury switch (see *Instruments*, Sept. 1936, page 247) is used in new "Type A" solenoid relay, available in 10- and 20-amp. non-inductive load capacity, on 115 volts a.c.

It is made in normally-open or normally-closed construction. The 10-amp. rating Type A relay with mercury switch is also furnished in single- or double-pole, normally open or normally closed construction, or in single-pole double-throw type.—*G. M. Laboratories, Inc., 1732 Belmont Ave., Chicago, Ill.*

REMOTE INDICATION *and* CONTROL



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TYPE 1 AUTOSYN MOTOR is a reasonably priced self-synchronizing motor with superior performance characteristics. One transmitter may operate as many as six receivers. Practically any system of remote indication or control may be solved by the selection of the proper type of Autosyn Motors.

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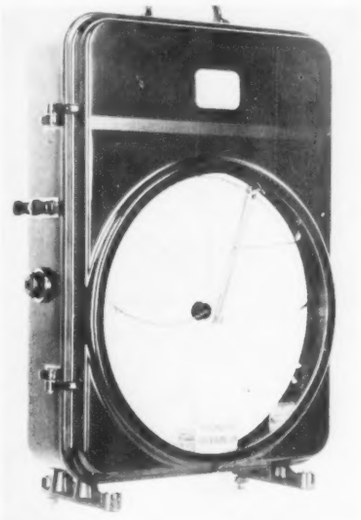
4. Safe continuous operating torque 5.6 inch ounces.
5. Brushes carry no current during synchronism.
6. Enclosed inertia dampener reduces oscillation to maximum of 3 seconds and is adjustable to suit.
7. Dimensions: 3-5/8"x3-9/16"x5-3/4".
8. Weight: 5 lbs., 12 oz.
9. Low current consumption and temperature rise characteristics.
10. Voltage range for accurate and safe operation, minus 20% to plus 10% normal rating.

Complete information on request.

BENDIX MARINE PRODUCTS CO., Inc.
(Subsidiary of Bendix Aviation Corporation)
754 Lexington Avenue
Brooklyn, N. Y.

Portable Pyrometer

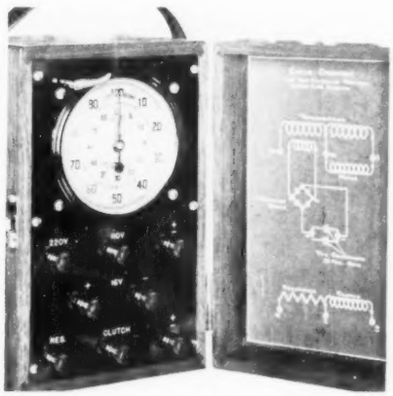
"Pyromaster" line of round-chart recording pyrometers (see *Instruments*, April 1937, page 97 for initial description; July 1937, page 172 for detailed technical description) has been enlarged



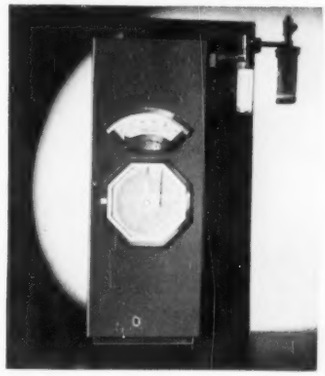
by the addition of portable model illustrated. New recorder does not require careful leveling, is said to be unaffected by vibration. Available as a pyrometer for ranges from 0-500°F. to 0-3000°F., also as a resistance thermometer for ranges from 20 to 350°F.—*The Bristol Co., Waterbury, Conn.*

Cycle Counter

Designed for measuring time of operation of high-speed electrical protective relays and apparatus, new "Model DC" cycle counter measures time in units of 1/100 sec. and 1/5 cycle. It is actuated



by a synchronous motor to which the hands are engaged and disengaged by means of a magnetic clutch. A self-contained rectifier with filtered output is built into the instrument so that the clutch circuit may be operated with direct current, thus eliminating the waveform error experienced when an a-c. clutch is used. This cycle counter will respond to intervals as low as 1/200 sec. with an accuracy of measurement in this interval of 85%.—*The Standard Electric Time Co., Springfield, Mass.*



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The latest developments in the measurement of CO_2 are incorporated in this new design of Republic CO_2 Meter.

The redesigned Republic CO_2 Meter incorporates the following important features:

- The CO_2 is measured by the Orsat method.
- Meter readings are free from the effects of temperature variations.
- The meter has a gas suction powerful enough to draw 14 inches of mercury. This eliminates the possibility of stoppage in the sampling line.
- The Republic Meter is driven by a fractional horse power motor and no water is required for its operation.
- A filter in the gas line removes all SO_2 before it reaches the meter.
- The large caustic tank holds enough potash to last from 4 to 6 months.
- The simplicity of the meter and its rugged construction eliminates the necessity for frequent servicing and adjusting.
- Hundreds of companies have used the Republic CO_2 Meter for many years and recognize it as standard for the mechanical measurement of CO_2.

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HÖPPLER VISCOSIMETER

For determining the ABSOLUTE viscosity of gases, oils, grease, varnishes, viscous tars or syrups, according to the *Falling Ball Principle.* Direct readings in Centipoises (or centistokes). Small sample (30 cc.) required. Results consistent and reproducible.

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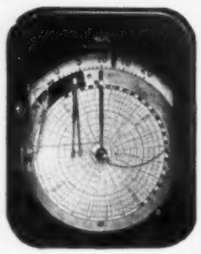

Hays CO_2 Recorder

Knowing the exact condition of the atmosphere in a heat treating furnace is vital in securing the results wanted.

For instance one user of a Hays CO_2 Recorder found that if the CO_2 content of his furnace was too high it had a case hardening effect upon his product due to absorption of carbon from the CO_2 which was disastrous to the quality of his product. On the other hand, too low a CO_2 content meant a serious fuel loss which he was anxious to avoid. Another user needs a neutral atmosphere to avoid oxidation and possible rusting of his product.

Where there is a heat-treating furnace there is a need for a CO_2 Recorder or Orsat Analyzer.

The Hays CO2 Recorder operates on the reliable Orsat principle of volumetric measurement and chemical absorption. Also records pressure, differential, draft, and temperature. Send for complete new catalog just off the press.

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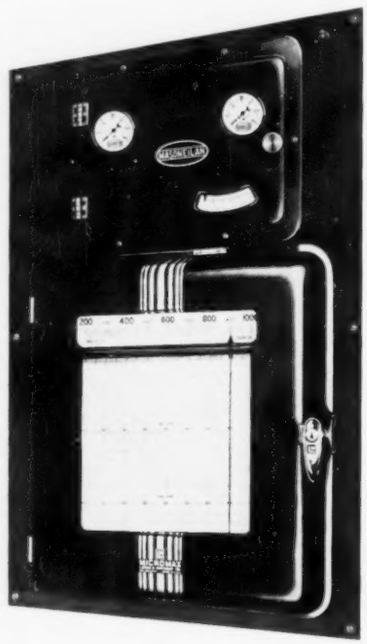
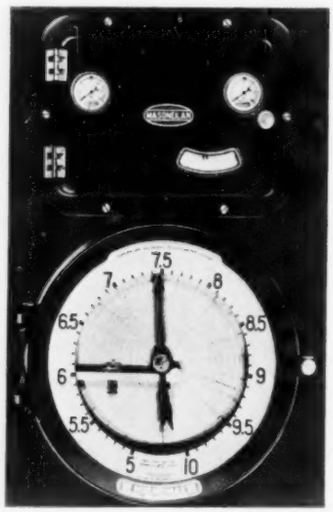
Air-operated Control Potentiometers

These new combinations of "Masoneilan" air-operated systems of control with the "L & N" potentiometer system of temperature measurement are designed



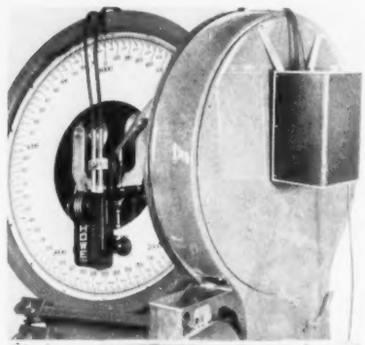
for refinery applications, solvent extraction units, gas- or oil-fired or electric furnaces and ovens, etc. Standard air-operated control units are available in three forms, all interchangeable, designated as Single-, Dual- and Drift-Compensated. In the single-compensated unit, compensation is taken from the control-valve diaphragm pressure to smooth out



sudden reactions which may be caused by rapid temperature changes. The dual unit adds to this control a compensation from a secondary medium such as steam pressure to a pump or gas pressure to burners. Fluctuations in processing media are thus recognized and compensated for before they upset the control. The drift unit adds a reset element, the speed of which is adjustable to process demands or lag. Combination equipments are available for use on 110-volt a.c., 25, 50 or 60 cycles, or for 110 or 220-volt d.c. Standard design calls for ranges between zero and 2,000° F. with single, dual or drift compensation available to specification. These ranges are designated for iron-constantan thermocouples, but other thermocouples and other ranges up to 3,000° F. are subject to specification. The air-relay system is independent of the electric system and there is no air bleed in the potentiometer case. An automatic locking device permits cutting out the control system or removing it entirely, without interfering with the potentiometer operation. Overall dimensions are approx. 32" high, 18¼" wide and 12⅝" deep. Control system requires approx. 20 lbs./in.² operating-air supply.—*Mason-Neilan Regulator Co., 1190 Adams St., Boston, Mass.*

Universal Cut-off for Scales

For automatic weighing and proportioning, new Universal Photoelectric Cut-off Attachment may be installed on any make of dial scale without altering or



re-adjusting it. Attachment consists of (1) optical unit held fast to glass front by three vacuum cups and (2) relay mounted on back of scale. Operating principle differs from that of usual photoelectric cut-off in that reflection of narrow light-beam is utilized, and no shutter-arm need be attached to pointer or other part of delicate indicating mechanism. Pointer movement over one scale division suffices to operate relay. More than one optical unit may be used on same dial to obtain combination and sequence of control (example, No. 1 for dribble and No. 2 for complete cut-off) with a minimum interval corresponding to 10 lbs. difference on a 24" or 30" dial.—Developed by *The Electronic Laboratory, 306 So. Edinburgh Ave., Los Angeles, Calif.* Announced by and available from *The Howe Scale Co., Rutland, Vermont.*

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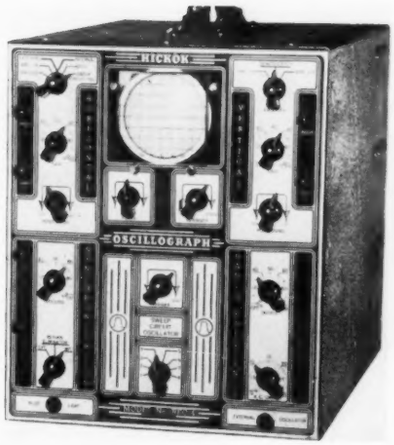

Oscillograph

Through addition of a self-contained demodulator, new Model RFO-4 is said to have "more than twice coverage of ordinary oscillograph." R-f., first detector and two i-f. stages can be thoroughly tested: instrument permits single or consecutive stage-by-stage trouble shooting from the antenna post to speaker. A self-contained electronic frequency modulator which simplifies connections and makes possible selectivity measurements has a variable width sweep from 0-30 kc., permits visual alignment at 665 kc. or any harmonic thereof to 5 Mc. without use of an external oscillator. With an external oscillator it produces an a-f. output continuously variable from 0 to 15 kc., also permits visual development of a-f. response curve. Among other features: return trace eliminator simplifying alignment of a-f. and r-f. circuits; horizontal amplifier for sweep expansion; high sensitivity horizontal and vertical amplifiers (0.2 volts/in.); trapezoidal patterns permitting percent modulation measurements; calibrated screen; adjustable cathode-ray tube rotation. Steel case (11″ × 13″ × 15″) shields oscillograph from external fields.—*The Hickok Electrical Instrument Co., Cleveland, Ohio.*

"Polaroid" Units

Development and commercial production of "Polaroid" large-area polarizing medium having led to increases in number and variety of applications, a corresponding increase in forms and sizes of mountings is announced. Illustration shows new rotating mount for use on any optical bench. This unit has calibrations for 180° marked off in 5° divisions. Quarter-wave plates are now available in similar mounts or in fixed mounts. Standard sizes of rotating units are 4-cm. and 6-cm. clear aperture. An 11-cm. clear aperture unit is announced for large work: it has 180° calibration with half-degree divisions.—*Polarizing Instrument Co., 8 W. 40th St., New York City.*

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WITH NO LAG
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COMPLETE SENSITIVITY ADJUSTMENT
1200° RANGE

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This GLASS ELECTRODE pH-meter measures hydrogen ion concentrations and reads direct from 0 to 14 in pH units . . . Sensitivity is 0.02 pH and working accuracy 0.05 pH . . . Rugged . . . Portable . . . Applicable for titrations and as a separate null indicator.

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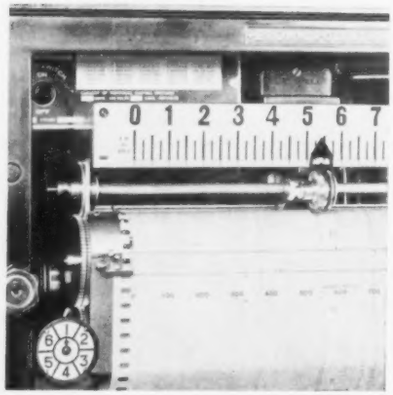
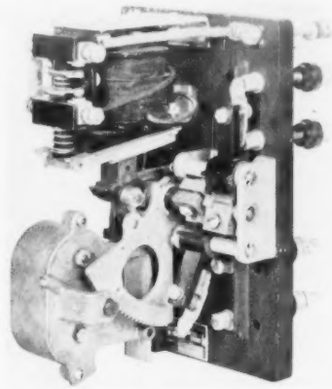


Color-numeral-printing Recorder-controllers

New multi-color numeral-printing models of maker's recording and recording-controlling potentiometers not only record up to six different temperatures in one of six different colors on a 12" chart, but they are said to be the only potentiometer pyrometers that can individually control all of these temperatures. Another unique feature is the chart drum which consists of a metal tube with a vulcanized rubber cover, as on typewriters, to insure clear printing. Print wheel is of heat-treated steel with machine-cut numerals. Instead of colored ribbon, new models employ an ink pad wheel where records are to be made in any one color, or ink cartridges of six different transparent, non-fading, aniline colors for multi-color records. Scale plate has been enlarged, has large bold figures in major temperature divisions for long-distance visibility, as well as a narrow, finely divided scale to permit precise reading of temperatures.—*The Brown Instrument Co., 4482 Wayne Ave., Philadelphia, Pa.*

Sequencing Relay

Designed to provide a reliable means of timing a sequence of several operations in a control system, a new definite-time relay employing a clutch-type time-delay interlock is available in a-c. or d-c. forms with two, four, or six circuits. Typical



applications of the CR2820-1729 relay include operating accelerating contactors, starting several motors at intervals to avoid excessive line current and starting different parts of machines or processes where delayed starting of some parts is desirable. New relay consists of a solenoid and a plunger mechanically connected to the time-delay mechanism and to a shaft that operates the contact fingers. On d-c. forms a separate small instantaneous cutout switch is mounted on front of solenoid. Positive and uniform operation is said to be assured by coil springs giving a constant pull on timing mechanism throughout entire operating cycle. By use of "free-wheeling" clutch principle on the time-delay mechanism, the relay is always in gear and accuracy is said to be maximal.—*General Electric Co., Schenectady, N. Y.*

Remote Re-setters for Temperature Controller

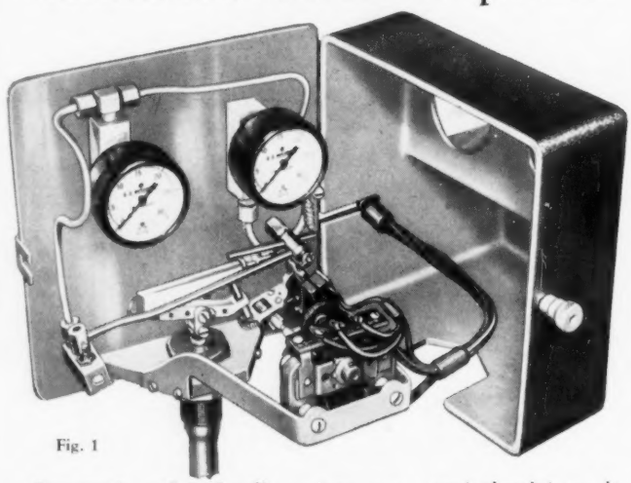


Fig. 1

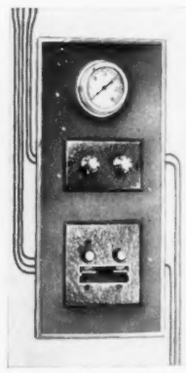
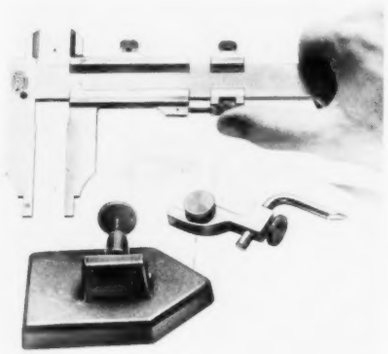


Fig. 2

Pneumatic and hydraulic systems are announced for changing, from a distance, the setting of the "All Range" bimetallic rigid-stem air-operated temperature controllers (see *Instruments*, Aug. 1936, page 216; Oct. 1937, page 254). Air-driven system is for use where fire or explosion hazards exist and where a 25-lb. supply is available. Electric system uses ordinary 110-volt a-c. supply. With either, control point can be reset any extent by operating remote push-buttons. Pressure to diaphragm-motor valve is indicated on same panel. Automatic safety devices are said to eliminate possibility of damaging any portion of system by improper manipulation or by over-travel due to extreme temperature changes. Working parts are corrosion-resistant.—*B. O. Bushnell, 541 N. Kings Road, Los Angeles, Calif.*

Caliper

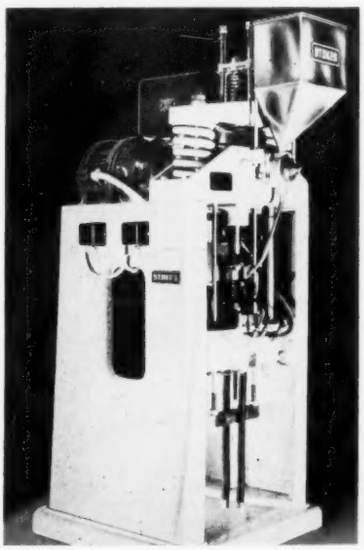
Particularly designed for toolmakers, a new caliper, graduated in 1/1000" and 1/128", is known as Type No. 537 with height gage combination. It comes in three sizes with measuring capacities of 7", 9" and 11". A base transforms it



into a height gage. Vernier has two knife edges which are practical for layout work, also for measuring distances between holes, root diameters of gears, etc. Scribing attachment may be firmly attached to the upper jaw. Its steel point is adjustable, making it possible to set height gage at an even figure of the scale when starting to measure. Positive cam lock is another feature.—*George Scherr Co., 128 Lafayette St. New York City.*

Automatic Molding

Complete automatization of molding of thermo-setting plastic materials has been accomplished in the press illustrated: with its hopper filled, it will automatically repeat its production cycle an indefinite number of times without attention; and if anything should interrupt continuity in discharge of finished parts it will automatically stop. Numerous measurement and control devices (of various makes) are employed for metering the feed of molding powder, adjusting the "breathing" (degassing), controlling curing time and mold temperature, etc. —*F. J. Stokes Machine Co., Olney P. O., Philadelphia, Pa.*



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A new, reasonably priced adaptation of the Wheatstone Bridge, convenient for:

1. Measuring specific resistance of electrolytes.

2. Ordinary A. C. Bridge resistance measurements.

Operates from A. C. power line. Accuracy is independent of line voltage variations. Cathode ray visual null indicator eliminates delicate galvanometer or inaccurate phones. Range for measuring electrolytes is .2 to 2,000,000 ohms; for ordinary resistance measurements the range is .2 to 250,000 ohms. A total of 70 linear inches of calibration. Completely self-contained.

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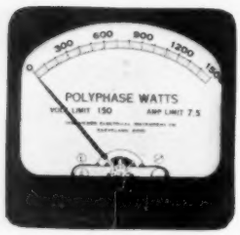

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Indicating Pyrometer and Thermocouples, for "those difficult applications." **Scale ranges as low as 0-400°F.**

THIS unusual Industrial Pyrometer has the same D'Arsonval Galvanometer movement, vibration-resistant hardened and ground steel pivots, sapphire bearings, safety glass front cover and splash-proof case as supplied for use in aircraft. *Full Cold-Junction and Copper Error Compensation.* Through the use of our Special Cobalt Alloy Magnet, enough torque is developed to allow full scale deflection over a range of 0-400°F.,with excellent response characteristics.

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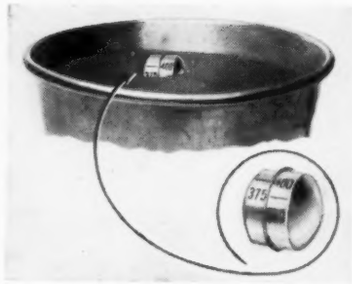


Floating Thermometer

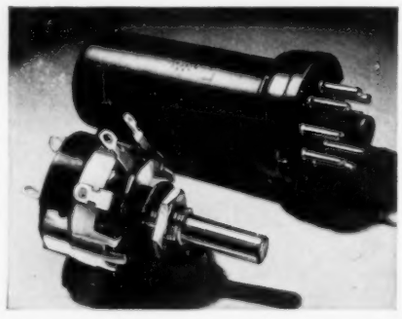
New "Thermosphere" is an all-metal non-breakable floating thermometer in the form of a small metal ball with a temperature scale engraved on the outside. Inside is a bimetallic mechanism which makes the Thermosphere rotate until uppermost number indicates the temperature. Standard model is 1½" in diam., chromium plated, with 350° to 400° F. scale. Size can be varied considerably and scale extended from 50° to 600° F.—*Mechanical Division, Raytheon Mfg. Co., 54 Willow St., Waltham, Mass.*

Signal Generator

New Model 581 Signal Generator and Frequency Modulator employs a 340° dial said to have an actual scale length of over 8 ft. New hairline indicating shadow-tuner spot-lights individual range desired, eliminating parallax. The 38 to 1 ratio between tuning knob and condenser accomplishes micrometer tuning. Emits (1) unmodulated r-f., (2) 400-cycle amplitude modulated r-f., (3) 24-kc. band frequency modulated r-f., (4) fixed 400 cycle a-f., (5) variable 0 to 10,000-cycle a-f. — *Supreme Instruments Corp., Greenwood, Miss.*

Midget Controls

New midget variable controls, Series 37, and Series 37-S (with switch), fit in assemblies where space is at a premium. Smooth operation is said to be achieved by an "ingenious contact arm." There is a 300° effective rotation. Improved technique in carbon coating is said to assure maximum immunity to moisture and climatic conditions. Units are available in linear and tapered resistance ranges from 1000 to 5 megohms. Total resistance values are held within ± 20%, closer when required. Maximum safe power dissipation for linear controls is 1 watt.—*Clarostat Mfg. Co., Inc., 285 N. 6 St., Brooklyn, N. Y.*



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New Applications of Comparison Microscope

By FRITZ RESCH

UP to the present time, there have been four possible methods for the determination of structural composition of alloys with known elemental constituents. Three of these involve the taking of microphotographs while the fourth uses only visual examination. The methods are as follows:

1. Cutting out with scissors constituents of a microphotograph and weighing the pieces of paper representing each of the constituents.
2. Determining areas on a microphotograph by use of a standard planimeter.
3. Using a metallographic planimeter.
4. Estimating approximately, by inspecting the sample visually through a standard metallographic microscope.

The first three methods require preparing a sample, making a microphotograph, and considerable work in order to accomplish the desired results. For example, in the case of an alloy containing a eutectic where the amounts of the two constituents might be nearly equal and where the constituents themselves are finely divided, the work involved is enormous. Then, too, the method of cutting up the constituents of a photograph by scissors, as well as the planimetric methods, require painstaking handling.

The use of the metallographic planimeter as described by E. P. Polushkin in the 1925 *Transactions American Institute of Mining and Metallurgical Engineers* is probably more rapid than either of the other methods and, as claimed by the author, "the results are accurate enough to justify the application of the method to many problems in metallurgical research instead of chemical analysis." It consists in scaling the microphotograph by a system of parallel lines drawn equal distances apart and determining the areas of the constituents from the fact that the ratio between the total areas of the various constituents within each strip is equal to the ratio between the sums of the medians of the trapezoids so formed:

$$\frac{\text{Area of Constituent } A}{\text{Area of Constituent } B} = \frac{\text{Sum of line segments for constituent } A}{\text{Sum of line segments for constituent } B}$$

If the specific gravities are known, the proportional weights of these constituents may be determined in the same manner:

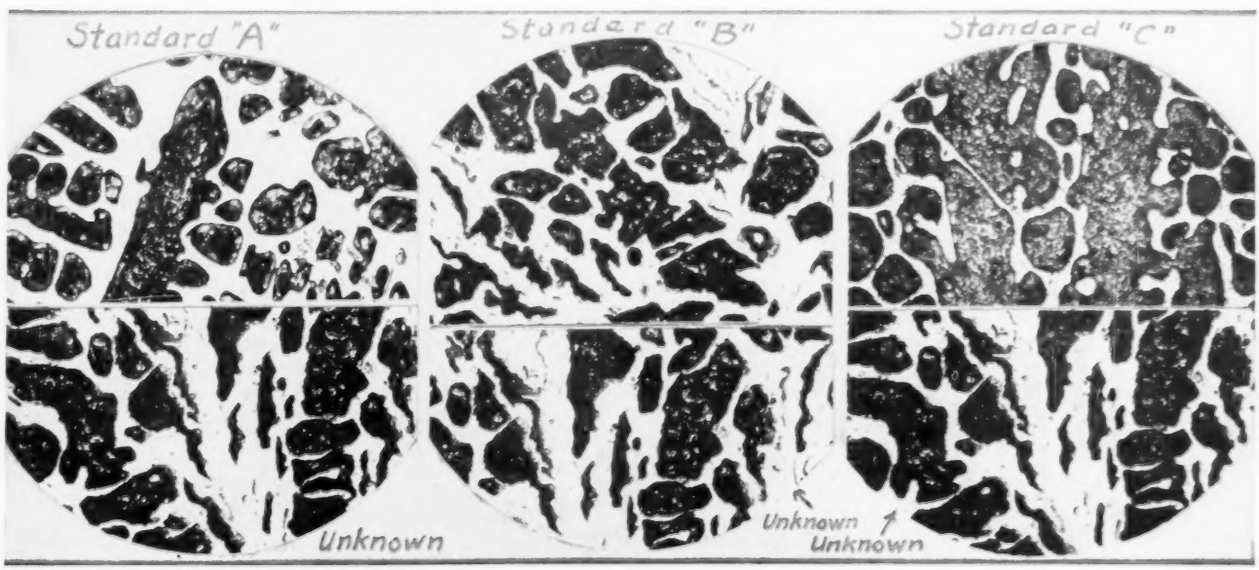
$$\frac{\text{Weight of constituent}}{\text{Sum of weights of 2 constituents}} = \frac{\text{Length of segments of } A \times \text{sp. gr. of } A}{\text{Length of segments of } A \times \text{sp. gr. of } A \text{ plus Length of segments of } B \times \text{sp. gr. of } B.}$$

If the density of the alloy and that of one of the constituents are known, that of the other constituent may be readily determined.

If the chemical compositions of the constituents are constant, the chemical analysis of the alloy being examined may be determined by this method or if the composition of the entire alloy is known and that of one of the two constituents is also known to have a constant composition, the composition of the unknown constituent may be determined.

The use of the fourth method, visual examination of single specimens under the metallurgical microscope, is limited by the fact that it is difficult for the human eye, unaided, to estimate the relative proportion of areas of the two constituents, especially if the observer is not working constantly on the alloy under consideration.

By reason of the time consumed in using the first three methods, and of the relatively inaccuracy of the fourth method, the use of the *comparison* microscope should be of considerable interest to those engaged in such work. The comparison microscope permits the examination of the unknown specimen at the same time



and in the same field as any one of a number of standards. A series of standards covering the entire possible range for the alloys being considered can be prepared from suitable samples and the amounts of the constituents can be measured by either the planimetric or the scissors method, the former being preferable. These standards can run from 0 to 100% of one constituent, or, if the entire range is not liable to be included in use, it can cover only that portion of the field which will be involved. Samples should be homogeneous throughout and after having the percentage of constituents determined accurately, should be mounted on a disk which can be revolved in position under one objective of the microscope, and suitably identified ("A," 'B," etc., or quantitatively).

The unknown sample is likewise prepared by the usual metallographic methods and is inserted under the other objective of the microscope. While the operator is viewing the unknown through the single eyepiece, he turns with one finger the disk containing the standards, and these appear one at a time on one half of the field at the same time that the unknown appears on the other half. When he sees the structure which corresponds most closely with that of the unknown, he stops turning the disk and records the percentage indicated on the standard sample which is then under the objective.

This method is admittedly not as accurate as that using the metallographic planimeter but is sufficiently accurate for routine examination on a mil scale for structural work. It has the advantage of enabling an operator to prepare and examine between ten and twenty specimens per hour as against the time of several hours necessary to obtain as accurate a determination of the percentage of the various constituents on one sample by any of the other methods.

In addition, the sample does not require as much time for preparation for this visual examination as when microphotographs are to be taken: grinding on three papers and on one wet emery wheel usually being sufficient.

Length of Spacer Ring in Convex-lens Elements

By GEORGE H. LOGAN

Sound Department, M.G.M. Studio, Culver City, Calif.

SO many present-day instruments incorporate optical elements in one way or another that their users who do some adjustment work or modifications are rapidly accumulating data, formulae, and short cuts to expedite their work. This short analysis is intended as a contribution to such material in that it derives formulae for the ready computation of spacer rings between the convex surfaces of two lens elements.

One of the most frequently recurrent yet simple optical systems is the double-convex lens, adaptable to either condenser or objective use. Double-convex lens characteristics are obtainable with a single element of two convex faces, or with two separate plano-convex elements as shown in Fig. 1. Use of two elements as illustrated is favored over the single double-convex element, because for a given aperture size it is known the former system is more efficient; that is, it collects more useful light.

The proper separation, s, between the convex surfaces is effected by placing a spacer ring in the lens mount as illustrated. Length b of the spacer ring is a function of s, of the elements' radii r_1, and r_2, and of the effective aperture, c. The formulae relating these quantities are derived below.

Referring to Fig. 1:

$$b = h_1 + h_2 + s$$

Now, the chord of a circular segment, c, is related to the height of the segment and the radius thus:

$$c = 2\sqrt{2hr - h^2}$$
$$\therefore\ c^2 = 4(2hr - h^2)$$
$$\therefore\ c^2 = 8hr - 4h^2$$
$$\therefore\ o = 4h^2 - hr + c^2$$

This is of the quadratic form. Solving for h:

$$h = (8r \pm \sqrt{64r^2 - 16c^2})/8$$
$$\therefore\ h = (2r \pm \sqrt{4r^2 - c^2})/2$$

From the $\pm$ sign before the radical in the above formula is noted that there are two possible values of circular segment height for a given chord and radius. This is visually clarified by reference to Fig. 2. When the $+$ sign is used, H is produced, and when the $-$ sign is used, h is given by the formula. In a lens problems, of course, it is only the minor h which is of concern. Therefore we can write:

$$h = (2r - \sqrt{4r^2 - c^2})/2$$

Hence, in Fig. 1:

$$h_1 = (2r_1 - \sqrt{4r_1^2 - c^2})/2$$
$$h_2 = (2r_2 - \sqrt{4r_2^2 - c^2})/2$$

Substituting these values in $b = h_1 + h_2 + s$

$$b = \frac{2r_1 - \sqrt{4r_1^2 - c^2}}{2} + \frac{2r_2 - \sqrt{4r_2^2 - c^2}}{2} + s$$

$$\therefore b = \frac{2r_1 - \sqrt{4r_1^2 - c^2} + 2r_2 - \sqrt{4r_2^2 - c^2} + 2s}{2}$$

$$\therefore b = (r_1 + r_2 + s) - \frac{\sqrt{4r_1^2 - c^2} + \sqrt{4r_2^2 - c^2}}{2}$$

Therefore, to obtain the length of spacer ring it is only necessary to substitute the known values in the formula for b above.

For the special case wherein the two plano-convex elements are identical; that is, when $r_1 = r_2$:

$$b = (2r + s) - \frac{2\sqrt{4r^2 - c^2}}{2}$$

$$\therefore b = 2r + s - \sqrt{4r^2 - c^2}$$

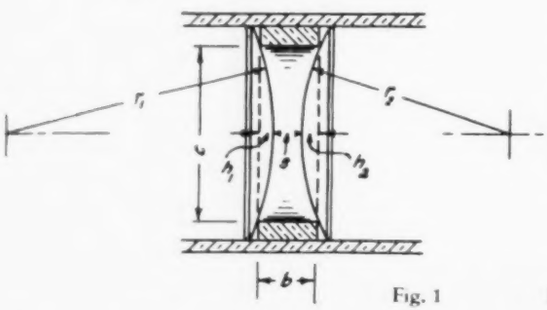


Fig. 1

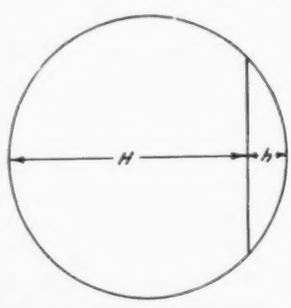


Fig. 2

A Sense-of-touch-operated Automatic Timer for Dark-rooms

By GEORGE H. HILL
Willimansett, Mass.

FORMERLY, when manufacturing name plates, a manufacturer using the so-called step-and-repeat process (for transferring a picture of a name plate from the original small photographic plate) depended upon a push button for turning on the light for each exposure and turning it off. With this arrangement, the operator would invariably press the button a little too long or not long enough, with the result that some prints were over- or under-exposed. The only thing that could be done was to wait until the printing and etching process was complete, and to throw out the defective name plates.

By reason of the sensitiveness of the photographic plate emulsion used in this manufacturing process, the exposure-time has to be exactly the same for each exposure when one particular original plate is being stepped up; but this exposure-time has to be changed for each individual original plate.

The market was thoroughly investigated and no exactly suitable automatic timer was found. Several were tried out on the job before the one described below was built. Few timers on the market can be set for intervals from a hundredth of a second to two or three seconds, or can repeat the exact timing for each setting consistently. Most of the precision timers are built around a small synchronous clock motor which is accurate enough in itself, but time is lost in setting the dial or when the motor engages the mechanism.

An automatic timer, to replace the push button, was made by rebuilding a Stromberg-Carlson telephone dial. All the telephone contacts and parts that operated them were removed from the bottom of the dial and replaced by contacts, springs, etc., as sketched in Figs. 1, 2, and 3. A mounting was made by using a wood base and a short piece of Micarta tubing.

The timer looks and operates like the original telephone dial, except that the contacts at the bottom of the dial are arranged to stay open when a number corresponding to the proper time is being dialed, and to close on the back travel. This lights the lamp until the dial has reached the end of its back travel, when the contacts open again and the light goes off. Therefore, when using this timer, it is only necessary to ascertain what number corresponds to the exposure-time desired and to dial that number for each exposure. If the exposure-time has to be changed for a different plate it is only necessary to dial a different number. Number "1" on the dial corresponds to the shortest exposure-time, and "0" to the longest. The timing for any number is always the same, however fast the dial is twisted forward by hand, because the dial return speed is controlled by a governor.

The most accurate commercially-available timers are equipped with a vernier-micrometer dial. Inasmuch as the timer for our process has to be operated in the dark, such dials are unsuitable. With some timers equipped with an adjustable stop, it was found that the stop would move if the knob was pushed against it a little hard. The percentage of the operator's time to operate such timers was found to be excessive. It takes "no time" (so to speak) to operate the telephone-dial timer in the dark room: the operator has previously placed a large steel ball in the hole over the number to be used, and he simply turns the dial until the ball strikes the finger stop. There can be no error this way, as it is impossible to change the setting without lifting the ball out of one hole and into another.

The "on" time range of the timer is the standard telephone dial speed. It is possible to adjust this speed (in addition to selecting any one of the ten tenths of the total duration) by adjusting the governor.

When used to operate a Mazda lamp in connection with the step-and-repeat process, it is not necessary to increase or decrease the speed of the dial if the time required should be longer or shorter than the time range of the dial. It can be apparently speeded up or slowed down by changing the intensity of the light.

For long exposure-times it is not always necessary to change illumination intensity or reset the governor: any number can be dialed more than once, giving 12, 14, 16 . . . or 12, 15, 18 . . . or 12, 16, 20 . . . or 15, 20, 25 . . ., etc.

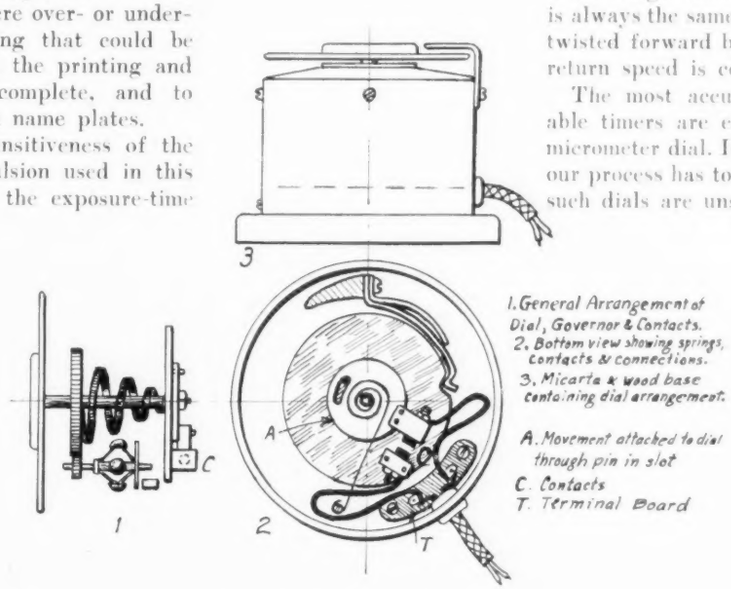


Fig. 4. Small Portion of a 9"x12" Negative With 216 Absolutely Uniform Prints.

Modern Scratch Hardness Methods

Eleventh instalment of "Hardness and Hardness Measurements." See page 1, Jan. 1937 issue

By S. R. WILLIAMS
Professor of Physics, Amherst College

BIERBAUM'S STANDARD INSTRUMENT

This instrument is also known as the Microcharacter. It will not be discussed from the standpoint of its being primarily an instrument for testing materials in quantity production, but rather from the viewpoint that it offers unusual advantages as an instrument of research.

Bierbaum's standard instrument is classified as a scratch instrument but, in thus classifying it, one must modify the term by indicating whether (1) the scratching or cutting point or edge ploughs the surface of the material to be tested so that portions are abraded (removed), or (2) whether substances are plastic and the material in the surface just flows out around the point or edge of the stylus without loss of material. As previously suggested, this seems to the author to be an important factor in the testing of materials by the so-called scratch methods. As will be shown later this question comes up in indentation methods. One recalls once more how easily the Indian was able to shear off portions of the flint with the softer bone tool, and how impossible it would be to make the bone penetrate the flint.

The Bierbaum standard instrument is one which makes the hardness of the material tested a function of the width of the microcut made by a diamond edge when the test surface is moved along under the diamond edge which bears down on the surface with a constant pressure. Usually a 3-gram mass holds the diamond on the surface to be tested. If the substance is exceptionally hard a load of 9 grams produces the pressure on the cutting edge. During the process of making the microcut, the edge of the diamond is lubricated with a superfine watch oil.

TABLE I—RELATION BETWEEN WIDTH OF MICROCUT AND MICROHARDNESS NUMBERS

STANDARD 3-GRAM WEIGHT

$K = \lambda^{-2}\ 10^4$ = Microhardness

λ = Width of Microcut in Terms of μ

μ	K	μ	K	μ	K	μ	K
50.0	4.0	13.0	59.2	8.6	135	3.6	772
47.5	4.4	12.8	61.0	8.4	142	3.5	816
45.0	4.9	12.6	63.0	8.2	149	3.4	865
42.5	5.5	12.4	65.0	8.0	156	3.3	918
40.0	6.3	12.2	67.2	7.8	164	3.2	977
37.5	7.1	12.0	69.5	7.6	173	3.1	1041
35.0	8.2	11.8	71.8	7.4	183	3.0	1111
32.5	9.5	11.6	74.3	7.2	193	2.9	1189
30.0	11.1	11.4	76.9	7.0	204	2.8	1276
28.0	12.8	11.2	79.7	6.8	216	2.7	1372
26.0	14.8	11.0	82.6	6.6	230	2.6	1479
24.0	17.4	10.8	85.8	6.4	244	2.5	1600
22.0	20.7	10.6	89.0	6.2	260	2.4	1736
20.0	25.0	10.4	92.5	6.0	278	2.3	1891
19.5	27.7	10.0	100	5.6	319	2.1	2268
18.5	29.2	9.9	102	5.4	343	2.0	2500
18.0	30.9	9.8	104	5.2	370	1.9	2770
17.5	32.7	9.7	106	5.0	400	1.8	3087
17.0	34.6	9.6	109	4.8	434	1.7	3460
16.5	36.7	9.5	111	4.6	473	1.6	3906
16.0	39.1	9.4	113	4.4	517	1.5	4444
15.5	41.6	9.3	116	4.2	567	1.4	5102
15.0	44.4	9.2	118	4.0	625	1.3	5917
14.5	47.6	9.1	121	3.9	657	1.2	6944
14.0	51.0	9.0	123	3.8	692	1.1	8264
13.5	54.8	8.8	129	3.7	730	1.0	10000

For a 9-gram weight use $\frac{1}{2}\ \lambda$

The formula developed for the instrument is,

$$k = 10^4/\lambda^2$$

where k is the microhardness number, λ is the width of the cut in microns and 10^4 is an arbitrary number used to avoid fractional microhardness numbers. When 9 grams is used as the load on the diamond edge, $\lambda/2$ is used in place of λ in the formula for k. As indicated, the width of the microcut is given in microns and is measured by means of a filar micrometer in the eyepiece of the microscope. Table I gives a series of readings, showing the relations between microcut width and microhardness numbers.

DETAILS OF THE MICROCHARACTER

Fig. 61 shows the instrument attached to a high powered microscope, put out by the Spencer Lens Co.[1] which also manufactures the microcharacter. Fig. 62 shows the

[1]Spencer Lens Company, Buffalo, New York.

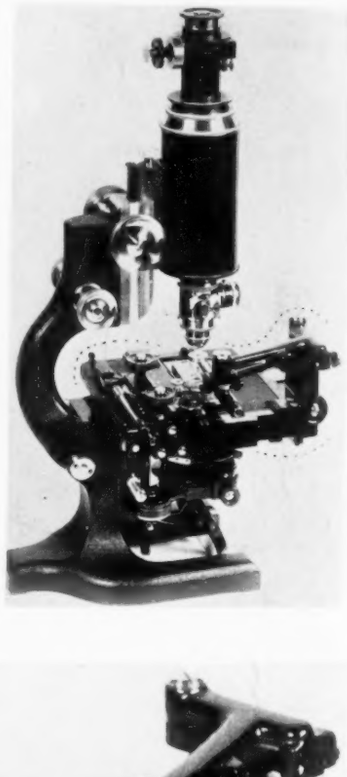


Fig. 61. Bierbaum's Standard Instrument—sensitive enough to measure differences in hardness between various crystalline grains in the same specimen (see Fig. 77). Dotted line encloses the Microcharacter proper.
Courtesy of C. H. Bierbaum

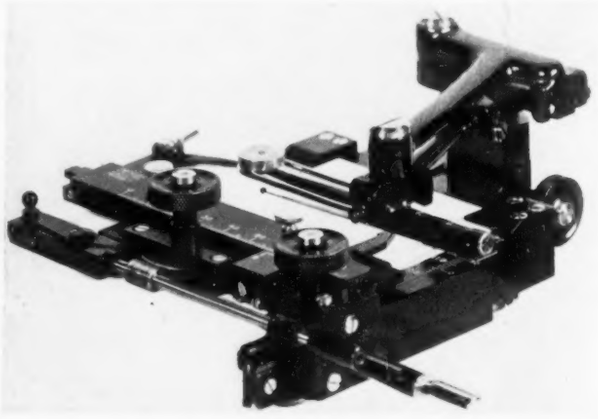


Fig. 62. The Microcharacter, not mounted on microscope or stand.

Fig. 63. Diamond point in position.

corner of a cube was finally adopted as being the most desirable, both for serviceability and also for offering the possibility for exact duplication."

In this last point it might be pointed out that thus far no specific directions have been given for duplicating the diamond edge used in the Graton instrument. Continuing Bierbaum's description:

"In order that the width of cut shall in all cases be a direct function of its depth, and the square of the width of cut be directly proportional to the cross-sectional area of such a cut, it is necessary, where the corner of a cube is selected, that its cutting point be exceedingly accurate, that the three facets be true, plane surfaces, that the three lines of intersection of these three facets be straight lines and that the point be without bluntness. The foregoing conditions are absolutely necessary in order that a rational scale of hardness may be established, one that shall apply equally well to all degrees of hardness of the various metals and thereby give accurate means of comparison for hardness."

"In order to make the work of different investigators of general value, it is also necessary that their results and data should be directly comparable, but this can only be accomplished by having like instruments of the highest degree of perfection."

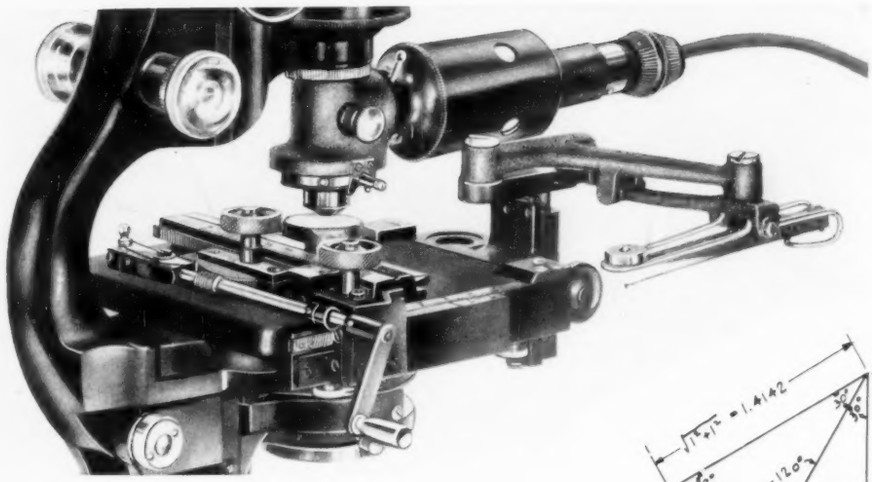


Fig. 64. Diamond point swung to one side. This figure shows also the vertical illuminator in position.

instrument unattached, while Fig. 63 shows the same instrument mounted on a special stand. The latter is for use with a microscope to which the microcharacter cannot be conveniently attached. (See also Fig. 64.)

The important part of the instrument is the diamond and the manner in which the cutting edge of the diamond is formed. Fig. 65 shows the draftsman's analysis of the shape in which the diamond is to be ground. After many years of experimentation it was found possible for a lapidarian[2] to cut a diamond to the required degree of accuracy. Inasmuch as the diamond edge is so important, Bierbaum's[3] own description of the grinding and finishing of the diamond will be quoted.

"A very considerable amount of study has been devoted to the shape and proportions of a suitable cutting point, not only as to the best and most efficient for such service requirements, but also with a view of enabling the duplication of a point under exact specification. After a somewhat prolonged investigation as to shape, proportions and angles for such a cutting point, the

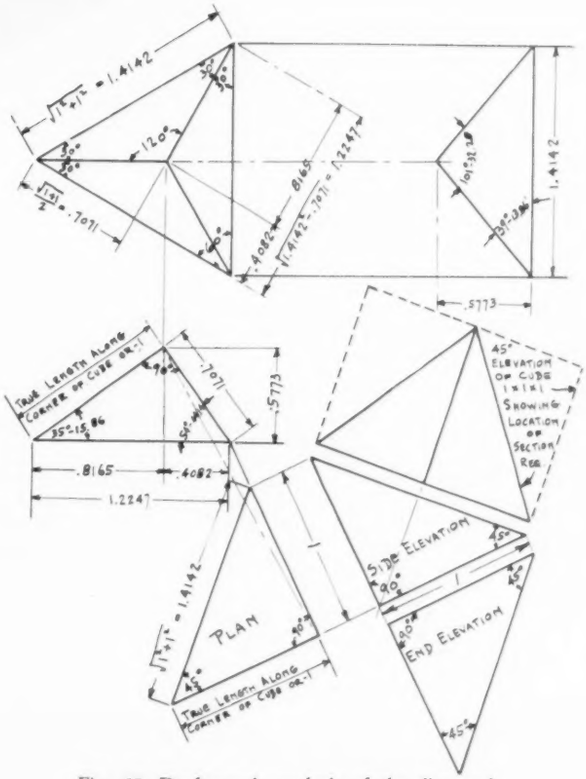


Fig. 65. Draftsman's analysis of the diamond.

[2]F. E. Gilmore, 112 Dartmouth Street, Boston, Massachusetts.
[3]C. H. Bierbaum. The Microcharacter. *Transactions American Society for Steel Treating*. Vol. 18, 1930, pages 1009-1026.

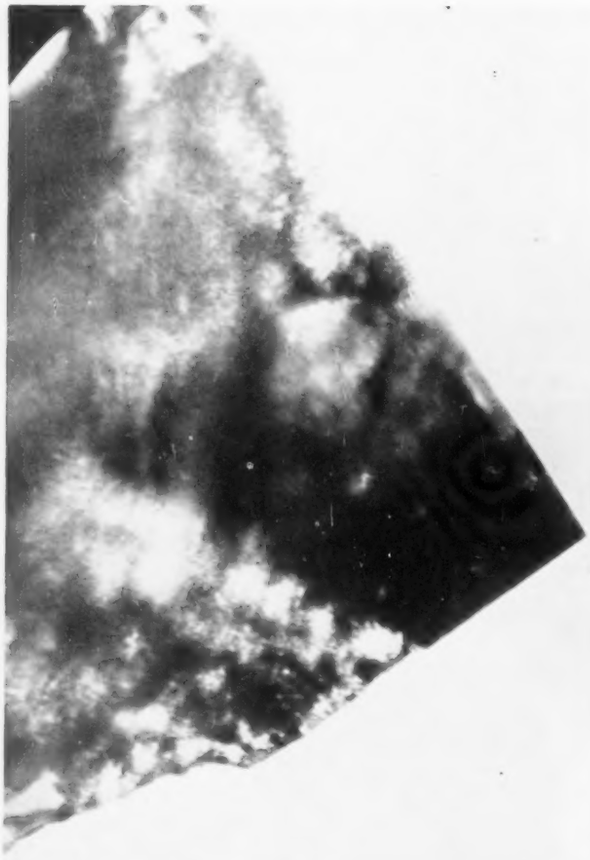


Fig. 66. Profile of the cutting edge of the diamond as used in Bierbaum's Standard Instrument.

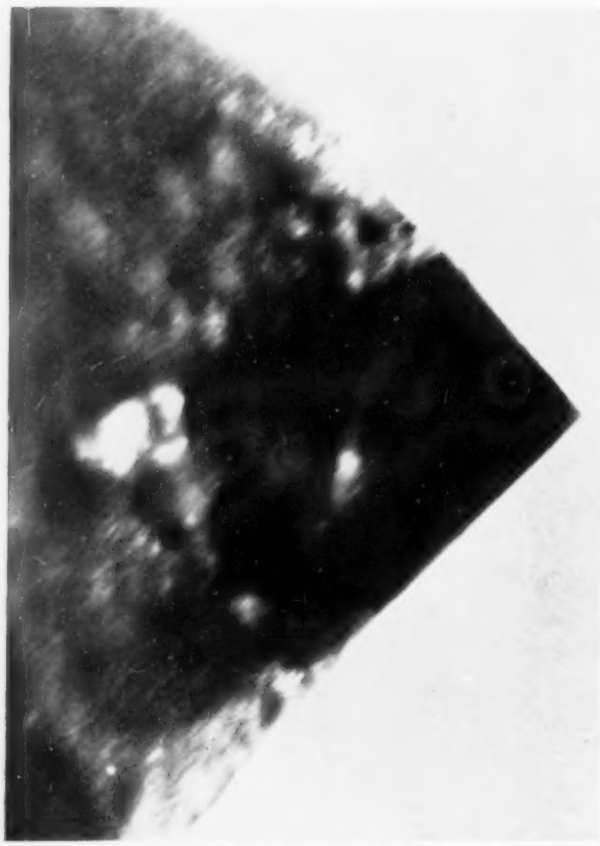


Fig. 67. The facet which is at right angle to the cutting edge of the diamond in Bierbaum's Standard Instrument.

After fifteen years of effort and experimentation, the inventor feels that he has accomplished this end. Not only must the manufacturer produce such an instrument, but each owner and operator of a microcharacter must keep a check on his diamond point. A diamond can be easily splintered if it is not taken care of. The author has made photomicrographs of his diamond before any use was made of it and will from time to time take others as a check on its cutting edge. The edge before the diamond was used in hardness testing is shown in Figs. 66 and 67. Fig. 66 shows the profile of the cutting edge. This is the edge shown to the right in the figure. In Fig. 67 one is looking at the diamond broadside and sees the facet at right angle to the cutting edge. It is this edge which will determine to a large extent the smoothness of the sides of the microcut.

To continue the quotation from Bierbaum: "These diamond points were found to be accurate when examined under a magnification of 2000 diameters. The facets were true plane surfaces, the three intersections formed by them were straight and smooth lines and each facet was a true right angle. These diamond cutting points are ground from small, irregular stones. After the proper axis has been selected, three facets are ground each mutually at right angles to the other and which form the corner to an imaginary cube."

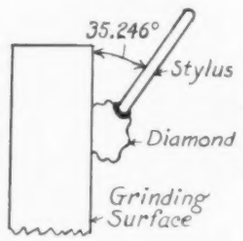


Fig. 68. Position of stylus with respect to grinding surface in order to form the proper cutting edge on the diamond. The diamond is set in the stylus in much the same way as any diamond is set.

Fig. 69. Mounting of the diamond edge in Bierbaum's Standard Instrument in order to secure uniform pressure to cutting edge.

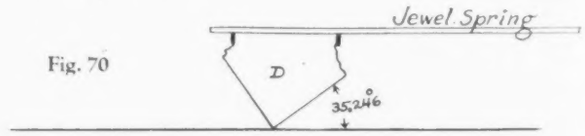


Fig. 70

The rough diamond is fastened into the end of a brass stylus. This stylus with the diamond is held in the grinding machine so as to make an angle of 35.246 degrees with the grinding surface. The stylus with diamond is shown in Fig. 68. After one facet is ground the stylus is rotated through 120 degrees and a second facet is ground. The repetition of this process a third time forms the third facet, which, combined with the other two, produce the corner of an imaginary cube.

The diamond as thus ground is mounted on the jewel spring as shown in Figs. 69 and 70. One of the edges, formed by the intersection of two facets, constitutes the advance cutting edge and is in direct line with the cut. This advanced edge makes an angle of 35.246 degrees with the test surface and is called the angle of incision. The depth of cut is supposed to be just slightly less than four-tenths of its width. Any bluntness of cutting edge would vitiate this last condition.

To be continued

INSTRUMENTATION FORUM

PROBLEMS — SOLUTIONS — DISCUSSIONS

SEPTEMBER PROBLEM (No. 11)
LOCATING BURIED TREASURE

We frequently are consulted on instruments for locating buried treasure. Most inquirers seem to be irresponsible. Among the exceptions are two . . . who desire quantitative data on the sensitivity and selectivity of each method.

DISCUSSION

By "A FRIEND"
WASHINGTON, D. C.

In connection with your Problem No. 11, a report recently received from the Berlin office of the Bureau or Foreign and Domestic Commerce on "The Geoscop: an Electrical Geophysical Surveying Instrument," may be of interest.

Extract from E & T 46:

"The Geoscop is a portable instrument, 7½" wide by 45" long and weighs 28 pounds. It is operated by three men, two carriers and a recorder. . . . It may be broken down easily into two parts for transport and can readily be assembled in the field. Power is supplied by a storage battery. The principal unit in the apparatus is **a secret assembly** said to be simple and inexpensive."

Extracts from 36-page German booklet:

(1) Extract from section entitled "Description": "The Geoscop is carried over the ground by two persons. Then by means of the extremely sensitive surveying apparatus, which is **screened from outside influences,** the influences occasioned by the underground geological structure are indicated by clear pointer deflections on specially designed instruments."

(2) Extracts from section entitled "Efficiency": "1. Dislocations . . . Not only outcropping dislocations, but those which are covered with sediments or eruptive material, are located through the covering layer. . . .

"2. As regards water-finding it may be stated that water circulation in the rock, *i. e.*, running cleft or pore water, can be 'detected' and yet water flowing on the surface or accumulated above clay beds does not exert any particular influence.

"The following points should also be noted: (a) with the Geoscop it is possible to discover non-metallic as well as metallic deposits, (b) it is possible to work with the Geoscop even in bad weather, (c) with the Geoscop it is possible to work in ground which is not open (wooded country), (d) high-tension electric wires have no influence on the action of the Geoscop, (e) **the effect of the apparatus is vertically downwards . . .**"

(3) Extract from one of the "Testimonials": "The instrument is extremely sensitive and registers very definite **deflections as soon as anyone approaches it.**"

EDITOR'S NOTE—The extracts were made by us; the bold-face type is ours. Here indeed is a wonderful instrument! It sees straight down into the earth; it tells what it sees; it is undisturbed by rivers, forests, high-voltage lines, etc. . . . Too bad that whoever edited the "Testimonials" in the German booklet forgot to strike out the statement implying that the approach of human bodies makes it go haywire!

$5 PRIZE DISCUSSION

By C. A. HEILAND
Professor of Geophysics, Colorado School of Mines
GOLDEN, COLORADO

Newspapers occasionally print items reporting the location of hidden treasure and even of orebodies by some sort of divining rod or "doodle bug." (There still are adults who believe that almost any kind of a hidden object can be located, by specially-gifted individuals, with a simple twig or some sort of a pendulum equipped with a cartridge filled with the sought material.)

Popular radio magazines occasionally print directions for the construction of treasure finders and radio equipment intended for the location of buried metal and ore. While the ideas underlying these designs may be essentially correct, such home-made gadgets generally fail to work: many technical factors beside a wiring diagram must be considered in their construction.

The object of the following discussion is to explain the fundamental working principles of treasure finders as applied to the location of shallow-buried metallic objects. As a rule, they are not suitable for the location of orebodies; for this purpose, different techniques apply which must be excluded from this description.

Treasure finders are applicable to the location of metallic bodies only. Generally speaking, the sought objects must have a difference in electrical conductivity or magnetic permeability from the surrounding medium. It would be hopeless to try to locate, by means of a treasure finder, a wooden box containing documents.

Two common features of all treasure finders (with the exception of the beat-frequency method; see below) are: (1) a

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Problem No. 13 — Subject Index 12.2

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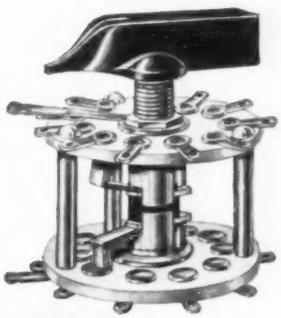

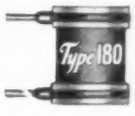

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coil for the generation of an electromagnetic field, and (2) another coil or pair of coils for the detection of the distortions of the electromagnetic field produced by conductive or magnetically permeable bodies. A further characteristic of most treasure finders (other than beat-frequency) is that the primary and secondary coils are so arranged with respect to each other than the effect of the former on the latter is zero when no field distortions exist.

Treasure finders developed at this time may be divided into two major groups. The first group embraces low- or intermediate-frequency devices (500 to 1000 cycles) while in the second group frequencies from 75 to 250 kc. are employed. The treasure finders in the first group are modified induction balances and those in the second group (other than beat-frequency) consist of small high-frequency transmitters and receivers with fixed spacing.

The induction-balance treasure finders are best suited to the detection of bodies of high magnetic permeability, *i.e.*, iron and steel objects. They may be divided into two groups: (a) the dual-coil, and (b) the triple-coil instruments (or induction balances proper). The dual-coil instruments consist essentially of two carefully balanced coils arranged in two symmetrical arms of a bridge. If an iron object is approached and the inductance of one of the coils is changed, the bridge balance is disturbed and the unbalance may be indicated by an amplifier with phones in the zero arm of the bridge. In the induction balances, three coils are wound concentrically on a non-conductive cylinder. The center or primary coil is energized and the two secondary coils are connected in series opposition and to an amplifier so that in the absence of iron and steel objects no signal is heard. When this coil assembly is carried over a portion of ground containing iron and steel objects, there will be an increase in the density of the lines of force which will affect the lower coil more than the upper coil so that a condition of unbalance and thus a signal will be produced. During and after the war, fairly extensive use was made of such devices in this country and in Europe for the location of arms, unexploded shells, etc.; with one of these instruments, shells weighing 17 lbs. could be located 2 feet under the surface. The depth limit of these induction instruments for small and medium-sized iron and steel objects is probably not over 5 feet.

In the second or high-frequency group of instruments, we may distinguish (a) the beat-frequency devices, and (b) the combined-transmitter-and-receiver instruments. In the former, two oscillators are employed: one of them of fixed frequency and carefully shielded; the second connected to a fairly large pick-up coil so that its frequency will change when metallic objects come within the range of that coil. With a change in the frequency of the oscillator connected to the pick-up coil, a beat frequency will develop which may be amplified and indicated by phones or a vacuum tube voltmeter circuit. Extensive use has been made of this principle for the detection of concealed metal about persons employed in mints or of weapons concealed by visitors to penal institutions, etc.

Most high-frequency treasure finders,

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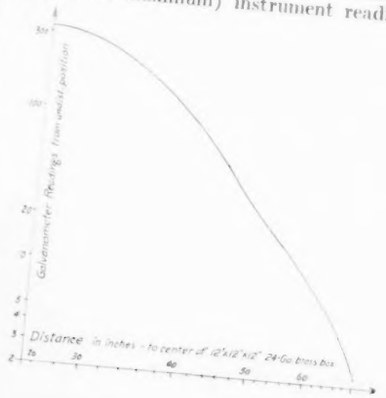
however, employ a combination of a high-frequency transmitter and receiver. Both are arranged at a fixed distance in a carrying frame and contain the transmitting and receiving coils so that the outward appearance of such devices is that of two boxes carried at the ends of a cradle, the operator placed between them. In one commercial type the relative position of transmitter and receiver is such that the direct effect of the former on the latter is a minimum: the transmitter box with coil is vertical while the receiver box with coil is horizontal. In another type, the transmitter box is slightly tilted from the horizontal and the receiver is tilted from the vertical so that, with the receiver unit forward, the deflections of an output indicator may be read conveniently by the observer while walking over the ground. In this type, the relative tilt is so adjusted that the undisturbed field produces maximum (or near maximum) instrument reading.



The transmitter consists generally of a two-tube oscillator with a frequency of 75 to 250 kc. and a one-tube modulator operating on a frequency of 500 to 1000 cycles. The receiving unit contains one stage of r-f. detection and a two- or three-stage transformer-coupled a-f. amplifier with a vacuum-tube voltmeter in the output circuit.

When a high-frequency treasure finder of such construction is carried over the ground and metallic objects are present, the transmitter field will induce eddy currents to flow in them; these currents in turn will tend to produce an electromagnetic field opposite to the primary field, so that in an instrument adjusted for maximum deflection with no conductors present, a sharp drop in the reading will be observed when directly over the conductive body.

In the high-frequency instruments, the indications depend primarily on the conductance and equivalent electrical size of the subsurface metallic bodies and their permeability appears to have little effect. The depth range for small buried metallic objects such as boxes, etc., is probably somewhat greater than that of the induction balances but does not exceed 10 feet. The accompanying figure shows the results of a test made with one of the commercial treasure finders on a brass box 12″×12″×12″ in size, arranged in air at various distances from the instrument. It is seen that the presence of a box of this size would be barely detected at 6-foot depth. Results under actual conditions would depend on the conductivity of the surface soil and the duration of burial.

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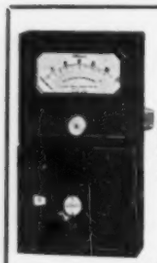

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the reading-depth curve shows that the reading decreases in proportion with the inverse 6th power of depth. This relation is probably not of universal significance and must be expected to change with the relative dimensions of the conductive body and the dimensions of the primary coil in relation to the distance between transmitter and receiver.

The lateral range of detection for the high-frequency treasure finders is estimated to be in the neighborhood of 4 to 5 feet for small conductive objects. In surveying a piece of ground it therefore is advisable to lay out parallel profiles with a distance not exceeding 10 feet.

The cost of a treasure finder survey depends essentially on the amount of ground to be covered, and therefore on the definiteness of information available as to the approximate location of the sought object. With no information of such character it obviously is out of the question to attempt to cover square mile after square mile. In geophysical oil exploration this procedure is justified because the structures to be located generally have dimensions of the order of several square miles. In treasure hunting the buried objects have dimensions of the order of inches or feet at the most, and the application of a treasure finder is useless unless some information is available to limit the area to be prospected. To cover an area of one square mile at maximum intervals of 10 feet would call for some 278,000 stations.

An efficient treasure finder is as much a precision instrument as a transit; and attempts of untrained persons to build such instruments should be definitely discouraged. The prices of commercial treasure finders range from $185 to $300. As far as the writer is aware, distributors do not make it a practice to rent their instruments at this time but undertake surveys on a consulting basis for responsible parties.

The future development in the treasure finder field will no doubt be in the direction of increased range. While it must be remembered that depth range is not a magnitude that can be stated in absolute terms, being dependent upon the conductivity (or permeability) and the dimensions of the sought objects, it is true that it depends, among other things, on the diameter of the primary coils and the distance of the transmitting and receiving units. The present performance of treasure finders results from a compromise between a practicable size of the apparatus and minimum depth range required. Progress in the direction of greater depth penetration will be possible by a greater separation of transmitting and receiving units. For this reason, one type of treasure finder is now made available in a form suitable for a separate transmitter and receiver setup. Such application of a treasure finder would therefore approach the technique now being used in the various fields of electrical geophysical ore prospecting.

*INSTRU*MERRIMENT

Conducted by Felix Melano, Instrumirthologist

In this department we print each month (mebbe) SERIOUS versions of various subjects treated with too much humor elsewhere in this mag. "Gravity, not levity"—that's our masthead motto. "Solemnity, not jocosity"—that's our sober slogan.

InstruMerrimenTerminology

Our first article is made possible by the boys in the Nameless Department of the Anonymous Co. They deplored the jollity with which instrument men view their work, and as a stimulus to earnestness they submitted a few technical terms—to which other thoughtful engineers have been adding, until the list is so long that we can only publish a part. Nevertheless we'd like to receive more from equally serious readers.

Ohm—Where the factory men go at five o'clock—the lucky stiffs!
Balanced Bridge—Symmetrical teeth.
Transformers—Brassieres, girdles, cosmetics, hair dyes, etc.
Burette—Small dresser.
Pipette—Small briar.
Pen Carriage—Police patrol wagon.
Pointer—A kind of dog. Hell, everybody knows that!
Hunting—Where you can use a good pointer.
Reset—Time out, so Teacher can phone her b. f.
Slide Rule—A way to look busy.
Erg—Annoy.
Report—Ask the man who writes one.
Full Throttlor—Intoxicated engineman.
Degree—Divorcée's trophy.
Low Range—Semi-monthly pay check.
Interferometer—Football official.
Adiabatic—Hospital case.
Optimatic—Cheerful outlook.
Range Tube—Any piece of stove pipe.
Stylus—Fashionable.
Comparator—One woman looking at another's clothes.
Bezel—A corner cut on an angle.
N.T.P.—National Tippler's Party.
Coefficient—What you do with a row boat and fishing tackle.
Magnet—A tiny bug.
Center Tap—Spigot on the middle barrel.
Flange Tap—A particular kind of dance.
Counter-current Exchanger—A bank employee.
Time Switch—Daylight saving.
Revolution—Foreigners' national sports.
Governor—Presidential dark horse.
Soft Copper—Good-natured policeman.
Dead Weight—A tombstone.
Vena Contracta—Five no-trump.
Bellows Assembly—Diving suit.
Spiral Shaft—Bow-legged woman's means of support.
Amp—A little devil.
Milliampere—Niece of Mike Rowatt.
Steam—Water gone crazy with the heat.
Ratchet—What to do when it itches.
Terminal Lug—A bum in a railway station.
Toggle—What the Romans wore.
Zero—Toggle-wearing fiddler.
Toggle Switch—Persuader for small children.
Sweep Circuit—Path traced by a vacuum cleaner.
Kinetic—Where Gene Tunney lives.
Lag—Connection between hip and foot.
Self-operating—Surgeon using a mirror.
Rangeability—What Newlywed wishes Mrs. N. possessed.
Sensitivity—Your pal's behavior when you touch him for a five-spot.
Error—What William Tell shot.
Harmonic Function—Glee club affair.
Dial—Map, pan, phyzog, etc.
Phase—Same as dial.
Variable—Any woman.
Stable—War Admiral's domicile.
Nozzle—What War Admiral does to you if you bring him some carrots.
Cycle—Speed cop's War Admiral.
Floating—Dead fish.
Fluctuating—Live fish.
Pilot—Stratosphere chauffeur.
Dashpot—Prize cup for 100-yard sprint.